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ABSTRACT

Traditionally, illustrations used in instruction have been concrete in nature with the learning outcome not always considered in the design of the illustrations. This study investigated whether concrete or abstract illustrations were more effective for supporting acquisition of abstract concepts in print media when evaluated by immediate and delayed testing. The 52 subjects, who were junior and senior teacher education students enrolled in an instructional design and development course, were randomly assigned to one of three study groups: no illustrations, concrete illustrations, and abstract illustrations. The researcher-developed materials used were three versions of a print-based lesson teaching the four categories within the intellectual skills domain of Gagne's domains of learning outcomes. Subjects were given descriptions of learning tasks and asked to identify which of the intellectual skills each task represented, i.e., discrimination, concept, rule, or problem solving. Materials for the abstract illustration group contained abstract representations of these four classifications, while materials for the concrete illustration group contained representations of "the best example" of the concept. The best example was also explained verbally in the text used by all three groups. The lesson design followed Gagne's nine events of instruction. The instruments for both the immediate posttest and the delayed posttest, which covered only the textual materials, consisted of parallel forms of questions assessing the classification of examples of each of the four learning tasks. Although no significant differences were found between the three groups, the gain from the immediate posttest to the delayed posttest showed that the abstract visuals tended to increase retention to a greater degree than the concrete visuals. (14 references) (Author/BBM)

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Abstract

Traditionally, illustrations used in instruction have been concrete in nature with the learning outcome not always considered in the design of the illustrations. This study investigated whether concrete or abstract illustrations were more effective for supporting acquisition of abstract concepts in print media when evaluated by immediate and delayed testing.

Introduction

The design of visuals for teaching concepts is an important issue for the instructional designer. Kirkpatrick as early as 1894 studied the retentional role of pictures through immediate and 72-hour delayed testing (Madigan, 1983). The results showed a positive superiority effect of pictures over words, especially in delayed testing. More recently, researchers have been evaluating the use of visuals in the teaching of concepts. The main focus of research has been on the teaching of concrete concepts with the use of concrete illustrations. However, this has left a gap in investigative research on the teaching of abstract concepts with the use of illustrations (Newby & Stepich, 1987).

Purpose

The purpose of this paper is to report the results of a study that investigated the question "What are the characteristics of effective instructional illustrations?" Specifically it investigated whether abstract or representational (concrete) illustrations were more effective in supporting the acquisition of abstract concepts.

Prediction 1

In the comparison of the illustrated versus the non-illustrated version of instructional text, it was expected that the illustrated version would be more effective than the non-illustrated version both on immediate and delayed tests. This effect was predicted due to two theoretical cognitive mechanisms of illustrations a) dual coding of illustrated information in the two representation systems of imagery and propositions (Paivio, 1986) and b) the attentional function of illustrations to the information represented within them (Duchastel, 1978; Peeck, 1987).

The dual coding theory suggests that even though the two subsystems work independently, one can have an effect on the other in terms of recall because of their partial interconnectedness. This implies that activity in one storage system can activate the other. If a bit of information which was stored both as an image and as a proposition cannot be retrieved from one storage area it may be retrieved from another, enhancing the retrievability of that piece of information. Based on this theory it can be predicted that information that is presented both as a image (whether concrete or abstract) and as text will be recalled better and longer than information that is presented only as text.

One primary mechanism for the advantage of illustrated over

non illustrated text is the attentional function of illustrations. Also, much previous research on other types of learning such as verbal information and concrete concepts has supported the illustrated over non-illustrated versions of instruction (Dwyer, 1978; Levie & Lentz, 1982; Merrill & Tennyson, 1977). Consequently, it seems that these benefits will also support acquisition of abstract concepts.

Visual information can be retained over a much longer period of time than textual information (Paivio, 1979). Studies have shown that, when compared to immediate testing, delayed testing of materials results in more of the visual portion of a text being remembered than that of the verbal (eg., Levie & Lentz, 1982). This indicates that the processing for visual information seems to be different from the processing for verbal information, supporting the dual coding theory of separate paths and storage systems for verbal and visual information, as well as, the superiority of imaginal over textual long term recall. (Paivio, 1979).

Prediction 2

The authors predicted that on immediate testing over the content; the students from the concrete visuals group would score higher than the abstract visuals group. The concrete visuals group was given an illustration of a "best example" which represented the attributes of the concept in a form that could be quickly and easily remembered (Newby & Stepich 1987). The superiority of the concrete illustrations over the abstract visuals in the immediate test was predicted because it was expected that it would be easier for learners to remember the relationship of "best example" to the criterial attributes of the concept immediately after instruction, than to relate the attributes to the abstract visual.

Prediction 3

It was expected that on delayed testing the abstract visuals group would score higher than the concrete visuals group. This result was expected because it was believed that over time, the relationship of the criterial attributes to the concept class would be more memorable for students who received the abstract illustration than for those who received the concrete illustration. It was expected that an abstract embodiment of the abstract criterial attributes would provide a superior over-arching schema that would encourage better recall of the attributes of the concept over the long term than the concrete, "best example" illustration. According to theories of knowledge representation that conjecture a hierarchical storage system, such as Ausubel's (1963), a super-ordinate concept should cue recall of more nodes than an individual instance stored beneath it.

Research Questions

On an abstract concept learning task:

1. Will both immediate and delayed performance of those who receive abstract illustrations be superior to those who received no

illustrations and will those who received concrete be superior to those who received no illustrations?

2. Will immediate post test performance of those who receive concrete illustrations in instruction be superior to the performance of those who receive abstract illustrations?

3. Will delayed post test performance of those who receive abstract illustrations in instruction be superior to the performance of those who received concrete illustrations?

Participants

The participants in this study were junior and senior teacher education students enrolled in an instructional design and development course at a southwestern university (22,000 enrollment) in the summer of 1990. This class was selected because of the content relevance, availability of students and the typical print-based method of presenting content. All students in the classes were asked to volunteer for the study, and 68 agreed (because of attrition only 52 completed the study) to participate and were randomly assigned to one of the three study groups (no illustrations, concrete illustrations, or abstract illustrations). The only requirement for participants to be eligible for this study was enrollment in the instructional design and development course and availability for delayed testing.

Demographic data/entry questionnaire was collected at the beginning of the research study through a survey given before the lesson. Participants fitted into the following categories: 14 males, 37 females (one person evidently did not know what gender s/he was!), 3 sophomores, 18 juniors, 21 seniors, 10 graduate students. The most common majors were, elementary education, early childhood education and secondary social studies education. The average participant age was 23, with ages ranging from 19 to 39. Forty-six percent of the students had had courses in learning theory. Seventy-five percent reported previous experience with Bloom's (1956), taxonomy and 69% with Gagne's (1984), types of learning outcomes. Yet, when asked what Gagne's types of learning outcomes were, only four percent remembered anything about them. It was determined from this survey that none of the students possessed sufficiently detailed prior knowledge of the content to be eliminated from the study.

Materials

The researcher-developed materials used for this study are three versions of a print-based lesson teaching the four categories within the intellectual skills domain of Gagne's domains of learning outcomes. The topic was chosen because of the abstract nature of the content. Also the topic filled the need for a subject that would be of value to the participants in the study, but did not assume much prerequisite knowledge or skill, thus increasing the motivation to learn the content. The instructional objective for the materials was: "Given a

description of a learning task, the learner will be able to identify which of the intellectual skills (i.e., discrimination, concept, rule or problem solving) it represents." The abstract illustration treatment (A) contained instruction with illustrations which abstractly represented each of the four classifications. For example, the concept "rule/principle" was abstractly represented by circles, arrows and a rectangle representing relational rules (see Figure 1). The concrete illustration treatment (C) includes illustrations representing "the best example" of the concept. For example, the concept "rule/principle" was concretely represented by a visual of balloons expanding in a hot car, illustrating the rule "a gas, when heated, expands in volume," (see Figure 2). The no illustration treatment (B) was instruction with no visual illustrations.

Figure 1

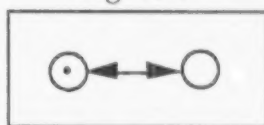
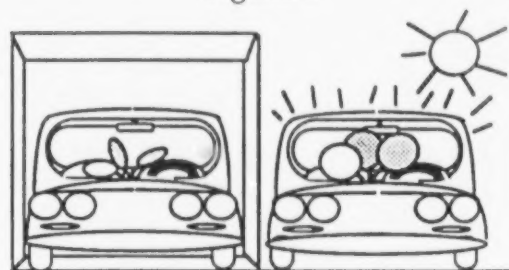


Figure 2



All three treatments have the best example explained verbally in the text as part of the lesson, due to the powerful effect of prototypes in concept learning (Newby & Stepich, 1987). Each set of materials for the study contained the same text content with the exception of sentences (two or three) that specifically referred to the illustrations, as traditionally recommended by Brody and Legenza, (1980). These caption sentences were constructed to convey no new content information.

The lesson design followed Gagne's nine events of instruction. It also incorporated Merrill and Tennyson's (1977) instructional design guidelines for teaching concepts. The Gagne's nine events are numbered and listed below along with the explanation of how each one was achieved in the stimulus lesson:

1. Gaining attention: The fact that this was not a normal classroom situation helped get the attention of the students. The researcher verbally explained the importance of the lesson content to the class and the instructions to be followed. Attention was also gained

in the initial textual references to the relevancy of the instruction to teaching tasks.

2. Informing the learner of the lesson objective was presented verbally in the first paragraphs of the materials.

3. Stimulating recall of prior learning: In the first paragraph of the lesson a reference to prior learning was made. "From your experiences in learning in all your years of public education as well as in the University you have probably noticed that there is a difference among learning tasks that have been assigned. Not only are some tasks harder, some take more time, some use different types of learning techniques."

4. Presenting the stimulus material with distinctive features: The lesson presented each distinctive feature (criterial attributes) of each of the learning outcomes (discriminations, concepts, rules and problem solving) and examples of each.

5. Providing learning guidance: Sentences were included to cue learners to effective learning strategies, such as: "use this example to help you remember..."

6. Eliciting performance: At the end of each section there was a review of the concepts being learned:

"Practice:

Please circle the numbers of the following examples which are evaluating learning of rules.

3. Which pronoun is correct? "The dinner club was too expensive for Jim and me/I".

In addition there is a cumulative practice at end of the lesson.

7. Providing informative feedback:

Informative feedback was placed at the end of each of the practice sections and at the end of the cumulation practice section, for example, "Questions 2, 3 and 4 are examples of concepts because students must classify according to characteristics and identify by the names 'propaganda,' 'Datsun,' and 'barn.'"

8. Assessing performance: Learning was assessed in the post test and the delayed post test.

9. Enhancing retention and learning transfer: The opportunity for learning transfer and reinforcement comes in the lesson, practice, review, post test and delayed post test. The post questionnaire and oral interview may also have been helpful in requiring the students to think about the use of the visuals in remembering the content of the lesson and how to use them in the future with formerly unencountered situations.

Tests

The testing instruments, both immediate post (range 0-30) and delayed post (range 0-31), for the instructional materials consisted of parallel forms of questions assessing classification of examples of each of the four learning tasks. The tests were over the textual content only.

The illustrations were expected to assist the students in recalling the information but there was no reference to the illustrations on the tests nor any question that could not be answered from the textual material. Similar questions (e.g. based on the same objectives) were given on both the immediate recall and delayed tests.

The first 24 test items on each test evaluated near transfer of the instructional objective by asking the students to classify concepts by selecting which one of the four intellectual skills that the statement represented. The following is an example of the test items: "How do you locate and fix the source of a problem of no sound in an audio system?" This intellectual skill is problem solving. The two tests used were parallel forms with equal number of each of the items testing conceptual knowledge of four concepts (four types of skill) on each of the two tests. The last part of the immediate post and delayed post test were six or seven far transfer items on each test, respectively. These items included making predictions and inferences based on concepts, explaining answers on categorization examples, explaining distinguishing characteristics in concept examples, supplying their own examples and explaining relationships among the related concepts with such questions as:

Which of these is the best strategy for learning the rule on use of pronouns? (Tom gave the bike to Bill and me.)

- ____a. Making flash cards with written statement of the grammar rule.
- ____b. Explaining the rule in written form.
- ____c. Developing your own examples of the use of the rule.
- ____d. Writing the rule 20 times.

The immediate post test score was chosen as a dependent variable to test information immediately after the lesson. The time period of one week was a logical choice for delayed testing because the information being tested would normally need to be stored in memory for about one week for use in the following class.

A post questionnaire using a Likert scale and completion questions were given after the immediate post test to determine attitudes and perceived understanding of the lesson and the illustrations. In addition, a 10% sample of the student participants from each treatment group was interviewed orally regarding their understanding and use of the illustrations between the immediate and delayed post-tests.

All materials developed by the researcher were read for validation of content by three instructional design experts in the educational technology area. Post test and delayed post test data from the study was used to obtain a reliability test of instrument at .70 and .66, immediate and delayed, respectively.

The test was scored by a key for the first 24 questions of each test and according to preset criteria for the last part of the test. If the answer did not meet the criteria for that question it was counted incorrect. There was no partial credit for a question.

Procedures

The class roll was used to assign the experimental treatments to the students by assigning the first person on the roll to the non-illustrated version, the second to the concretely illustrated version and the third person to the abstractly illustrated version, and so on.

Data collection occurred on three separate days. The first day of the regular class period of the semester consisted of the completion of an agreement to participate (strictly voluntary) form and the collection of demographic data/entry questionnaire for use in reporting information about the participants and any prior knowledge of the lesson content. On the second meeting day the instructions and the purpose for the lesson were explained before the lesson started. The lesson was placed in a brown envelope with the person's name and the last four digits of his/her social security number on the outside. The materials inside were given a unique identification number. The materials were color coded by treatment type and by lesson versus test to help with the instructions. When the students completed the lesson they replaced it in the envelope before removing the immediate post test. When the posttest was completed the students filled out the post questionnaire, placed all the material back in the envelope and left.

The unannounced delayed posttest was given one week after the immediate posttest. The delayed test was placed in the same envelopes in which the lesson and immediate posttest were placed and assigned the same packet's unique number to pair up other data with the posttest results.

A ten percent sample of the population was interviewed after the immediate posttest to gain more information on the way in which the participants used/did not use the visuals in the lesson. The questions asked in the oral interview were taped for accuracy in reporting. The questions consisted of the students' use and need for the visuals in remembering the lesson content. A sample question was "Did the illustrations help you remember the information?"

Variables

Independent variable

The independent variable in this test was type of illustration with three levels: none, concrete and abstract. These variables were embodied in three print-based instructional versions of a lesson on one of Gagne's domains of learning outcomes, intellectual skills. Each lesson was identical except for the presence of abstract illustrations, concrete "best example" illustrations or no illustrations. Both illustrated versions had the same pattern of layout of verbal information on two thirds of the page on the right side and visual

information or white space on the left one third of the page. Textual information referring to the illustrations was placed in the same pattern on each illustrated version.

Dependent Variable

The dependent variables in this study were immediate and delayed post test scores discussed under the test section.

Design

The design of this study was a immediate-test-post-test control group design. Data was analyzed with a one-by-three way factorial analysis of variance (ANOVA). The illustration variable had three levels: none, concrete and abstract. The dependent variables were immediate and delayed post-test scores. This design is shown in Figure 3.

Figure 3

		Design		
		Illustration Factor		
		abstract	not present	concrete
Immediate testing		N=17	N=16	N=19
		Illustration Factor		
		abstract	not present	concrete
Delayed testing		N=17	N=16	N=19

Results

The means and standard deviations were computed for each group as shown in Table 1 for the immediate post test and Table 2 for the delayed post test. A 1 X 3 factorial analysis of variance for the immediate post test resulted in ($F=2.0$, $df=2$, 49 , $p=.15$) and for the delayed post test ($F=0.45$, $df=2$, 49 , $p=.64$). The alpha level was set at the .05 level of significance. The results were not statistically significant.

Table 1
Immediate Post Test

Group	N	Mean	Standard deviation	range
A	17	21.65	4.21	11-28
B	16	21.44	4.2	11-28
C	19	23.68	2.71	20-28

Table 2
Delayed Post Test

Group	N	Mean	Standard deviation	range
A	17	23.24	3.73	14-30
B	16	22.63	3.88	14-28
C	19	23.79	3.31	18-29

Prediction 1 stated that the illustrated versions would be more effective than the non-illustrated version on both immediate and delayed tests. The results showed that the participants receiving the abstract and the concrete versions of the instructional lesson did better on both the immediate and delayed tests than participants receiving the non-illustrated version, although the actual statistical comparison of these data was not computed since the overall F was not significant.

Prediction 2 stated that on immediate testing over the content; the students from the concrete visuals group would score higher than the abstract visuals group. The results showed that the participants receiving the concrete illustrations did tend to score higher on the immediate tests than the participants receiving the abstract illustrations. However, this comparison of these data was not computed since the overall F was not significant.

Prediction 3 stated that it is expected on delayed testing the abstract visuals group will score higher than the concrete visuals group. The results showed that the participants receiving the abstract illustrations scored lower than the participants receiving the concrete illustrations.

The data were subjected to a posthoc analysis to analyze the gain scores from immediate post to delayed post, which showed the abstract groups' mean difference tended to gain more over time than both the concrete and non-illustrated groups. Also the non-illustrated group tended to gain more than the concretely illustrated group. These results were not statistically significant to the .05 level ($F = .36$, $df = 2,48$, $p = .7$).

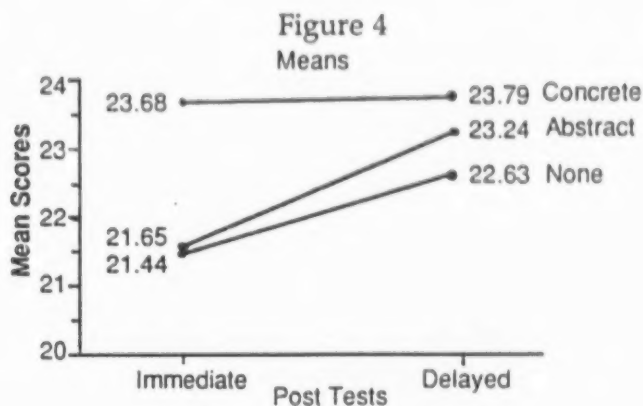


Figure 4 shows a line graph of the means of immediate and delayed post test scores over a one week period. Table 3 shows the means of the gain between the immediate and delayed for the three groups are: 1.59 for the abstract group, 1.19 for the no illustration group and 0.11 for the concrete illustration group.

Table 3
Means and Gain

	Abstract Illustration N=17	No Illustration N=16	Concrete Illustration N=19
Tests	Means	Means	Means
Immediate Post	21.65	21.44	23.68
Delayed Post	23.24	22.63	23.79
Gain from I P to D P	1.59	1.19	0.11

Discussion

This study investigated the comparative effects of concretely illustrated instruction versus abstractly illustrated instruction on the acquisition of abstract concepts. "On an abstract concept learning task will immediate post test performance of those who receive concrete illustrations in instruction be superior to the performance of those who receive abstract illustrations?" Although the data tended to support the conclusion that concrete > abstract on immediate post-test, these differences were not statistically significant. These findings somewhat support the findings of prototype "best example research". In addition, although abstract illustrations < concrete on delayed testing, it was indeed interesting, that the abstract visuals tended to increase retention to a greater degree than the concrete visuals as shown by the gain from Immediate posttest to delayed post (see Table 3). This finding will be followed up in later studies.

There are several factors that may have limited the robustness of this study. The lesson was written in such a way that was not difficult with or without visuals. For instance the non-illustrated group's mean performance was 22.3 (out of 30) which was quit high. The abstract visuals may have been too detailed or the verbal description of them not detailed enough. Because of the preliminary evaluation of the materials the researchers came to the conclusion of the need for further evaluation of both the test content and abstract and concrete visuals used.

In conclusion many factors have been found to affect learning with the use of illustrations in instructional text: the learning outcomes desired, the methods of presentation, the type of verbal reference to the illustration with captions and/or labels and/or direct reference within the text, how text relevant the illustration is and how dependent the content is on the illustration. These factors should be

controlled in further research with the learner's characteristics, such as reading ability and visual literacy, in mind. Much research on illustrations is still needed to sort out all the factors involved in the use of illustrations in instructional text. No matter what style of illustration is chosen, insuring that the illustrations provide the conditions needed to support each particular type of learning seems to be the deciding factor in designing illustrated instructional text.

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